

## Variation in work tasks in relation to pinch grip strength among middle-aged female dentists

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### ABSTRACT

**Objectives:** We aimed to investigate the relationship of task variation during dental work history with pinch grip strength among dentists.

**Methods:** We measured pinch grip strength among 295 female Finnish dentists aged 45–63 years. Variation in dental work tasks during work history was empirically defined by cluster analysis. Three clusters of task variation emerged: low (most work time in restoration treatment/endodontics), moderate (about 50% in the former and 50% in prosthodontics/periodontics/surgery), and high (variable tasks including administrative duties). Hand radiographs were examined for the presence of OA in the wrist and each joint of the 1–3rd fingers. Information on hand-loading leisure-time activities, and joint pain was obtained by questionnaire. Glove size was used as a proxy for hand size. BMI (kg/m<sup>2</sup>) was based on measured weight and self-reported height.

**Results:** Dentists with low variation of work task history had an increased risk of low pinch grip strength in the right hand (OR 2.3, 95% CI 1.2–4.3), but not in the left (1.13, 0.62–2.08), compared to dentists with high task variation, independent of age, hand size, hand-loading leisure-time activities, BMI and symptomatic hand OA.

**Conclusion:** The dentists with the most hand-loading tasks were at an increased risk of low pinch grip strength, independent of e.g. symptomatic hand OA. It is advisable among dentists to perform as diverse work tasks as possible to reduce the risk of decreased pinch grip strength.

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### 1. Introduction

Pinch and power grip are essential indicators of hand function (Chaisson et al., 1999; Bagis et al., 2003). Gender, anthropometric factors and occupational loading have been found to affect grip strength which declines with age (Ranganathan et al., 2001a; Angst et al., 2010; Samuel et al., 2012). The impact of occupational hand loading on pinch grip strength is not well understood. Josty et al. (1997) found that heavy manual workers had the highest pinch grip strength, office workers the lowest, and light manual workers were between these two groups. In contrast, a history of manual work with high physical loading may lead to a decrease in hand strength (Russo et al., 2006). To our knowledge, no study has examined the effect of different types of dental work on hand function.

Dentists often perform repetitive work tasks with a high demand of precision and pinch force. The work tasks in dentistry

differ with respect to mechanical loading on the finger joints (Milerad et al., 1991; Åkesson et al., 1997). Dentists heavily utilize the thumb, index, and middle fingers in precision gripping in the right (or dominant) hand, while the left hand remains static for supportive work tasks.

Chronic diseases affecting the hand may also lead to decreased pinch grip strength (Carmeli et al., 2003; Bagis et al., 2003). We have reported that symptomatic OA was associated with an increased risk of low pinch grip strength in middle aged women (Ding et al., 2010). A potential role of physical activity in attenuating the loss of grip strength has been suggested (Kjeken, 2011; Klum et al., 2012).

A correlation between anthropometric factors and pinch grip strength has been reported. In previous studies, hand length, palm length, and wrist and hand circumference were associated with hand grip strength (Anakwe et al., 2007; Li et al., 2010). A positive correlation was also observed between BMI and hand grip strength among overweight women (Ravisankar et al., 2005).

The objective of the present study was to investigate the association between variation in dental work task history and pinch grip strength among middle-aged female dentists. We assumed

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that low variation in dental work tasks is related to low pinch grip strength independently of symptomatic hand OA. As the right hand is more loaded than the left hand during dental work, we also assumed that the effect of low variation in work tasks on pinch grip strength will be more evident in the right hand than in the left. We further examined whether hand size, BMI and leisure-time hand-related physical activities might confound the potential association.

## 2. Materials and methods

### 2.1. Study samples

The subjects were randomly selected through the registers of the Finnish Dental Association, with aged 45–63 yrs in Helsinki and its neighbouring cities. Of those who received the questionnaire (in 2002), 295 (67.7%) dentists participated in a clinical examination between October 2002 and March 2003. Participation in the study was voluntary and based on informed consent. The Hospital District of Helsinki and Uusimaa Ethics Committee for Research in Occupational Health and Safety approved the study proposal.

### 2.2. Pinch grip strength

Tripod pinch grip strength (later: pinch strength) of both hands was measured between the pulp of the thumb in opposition to the pulps of the index and middle fingers, using the Martin Vigorimeter® with a small ball. The Martin Vigorimeter is one of the instruments frequently used to assess grip strength in clinical and research settings (Mathiowetz et al., 1985; Hamilton et al., 1994; Haidar et al., 2004). The Vigorimeter showed good validity and reliability (Jones et al., 1991; Desrosiers et al., 1995).

The test was administered during the clinical examination session by a researcher trained for the purpose. The measurement was performed first on the right and then the left hand. The subjects were seated in a chair with back support, feet on the floor, and hands on the table in a neutral position. The elbow of the hand to be tested was fixed at 90°. The subjects received a verbal instruction to squeeze the ball as hard as they can. Subjects were asked to make two maximal contractions. If the second contraction was more than 10% higher or lower than the first, a third contraction was made. The highest reading was taken to represent the subject's pinch strength.

The unit of measurement was kilopascal (kPa). The lower 25th percentile of pinch grip strength ( $\leq 52$  kPa) was used as the cut-off point to define low pinch strength of the left and the right hand. The great majority of the subjects were right-handed (eight persons, or 2.7%, were left-handed).

### 2.3. Definition of symptomatic hand OA

Both hands of the participants were radiographed. The analogue radiographs were evaluated by an experienced radiologist who was blinded to the age, and all health data of the subjects. Each distal interphalangeal (DIP), proximal interphalangeal (PIP), thumb interphalangeal (IP), and metacarpophalangeal (MCP) joint of both hands, and the wrists as a unit, were graded separately using a modified Kellgren and Lawrence scoring system with reference images (grade 0 = no OA; ..., grade 4 = severe OA). The weighted intra-observer Kappa-coefficients of the readings varied from 0.59 to 1.00 indicating good reliability (Solovieva et al., 2005).

Information on pain in each joint was collected by a self-administered questionnaire, with the question: "Please point out in the picture below, in which finger joint did you feel pain or tenderness during the past 30 days"? The subject graded the joints with pain from 0 = never to 3 = severe on a figure of the hands.

In the current study, symptomatic hand OA, or jointwise co-occurrence of radiographic findings and pain, was defined as follows: the subject had both radiographic findings (grade  $\geq 2$ ) and pain (grade  $\geq 1$ ) in at least one corresponding joint in the 1st (thumb), 2nd (index), or 3rd (middle) finger or in the wrist. The reference group consisted of subjects without symptomatic hand OA in the first three fingers or in the wrist.

### 2.4. Dental work history assessment

Based on a panel discussion with three experienced dentists and a professor in odontology, the main tasks in dentistry were listed and ranked by decade from the 1960s onwards, with respect to loading on the hands (0 = no load, ..., 10 = maximum load). Changes in working techniques and instruments were also considered. Six main tasks in dental work were identified: (1) restorative treatment and endodontics, (2) orthodontics, (3) periodontics, (4) prosthodontics, (5) surgical treatment, and (6) other non-treatment activities (e.g. dental examination, consulting, and administrative tasks).

Information on dentist's work history was collected by questionnaires and checked by interview during clinical examination. The study participants were asked to recall their work history in 10-year periods (at the ages of 25–34, 35–44, and 45–54 yrs) in terms of average number of working hours per week, and the proportion of time (percentage) they performed each task during an average working day. A matrix of workload coefficients for different tasks and time periods has been reported previously (Vehmas et al., 2005). Dental filling and root treatment was ranked as highest loading task among all dental work tasks.

Based on the weekly hours of work tasks 1–5, the pattern of tasks during work history was empirically determined by cluster analysis. Three clusters were identified: 1) low variation: the dentists who had spent most of their work time on restoration

**Table 1**

Distribution of subject of characteristics by the level of variation in dental work tasks.

	Level of variation in dental work tasks <sup>a</sup>			P-value*
	High variation (N = 96)	Moderate variation (N = 64)	Low variation (N = 131)	
<i>Continuous variables (mean, SD)</i>				
Age (years)	52 ± 6	54 ± 6	54 ± 6	<b>0.02</b>
Current BMI (kg/m <sup>2</sup> )	23.8 ± 3.0	24.4 ± 3.2	23.8 ± 3.4	0.38
<i>Categorical variable (n, %)</i>				
Hand-loading				0.13
leisure-time activity				
Low	19 (19.8%)	20 (31.3%)	40 (30.8%)	
High	77 (80.2%)	44 (68.8%)	90 (69.2%)	
Hand size				0.55
Small	34 (35.4%)	16 (25.0%)	45 (34.4%)	
Medium	55 (57.3%)	45 (70.3%)	78 (59.5%)	
Large	7 (7.3%)	3 (4.7%)	8 (6.1%)	
Symptomatic OA in the joints of 1–3 finger or the wrist				
Left hand				0.20
No	92 (95.8%)	58 (90.6%)	117 (89.3%)	
Yes	4 (4.2%)	6 (9.4%)	14 (10.7%)	
Right hand				0.11
No	90 (94.7%)	55 (85.9%)	114 (87.0%)	
Yes	5 (5.3%)	9 (14.1%)	17 (13.0%)	

\* P-value for the comparison between groups with different level of variation in dental work tasks.

<sup>a</sup> level of variation in dental work tasks: High variation: dentists who had performed variable work tasks; Moderate variation: dentists who had spent half of their work time on restoration treatment and endodontics, and another half on prosthodontics, periodontics, and surgical treatment; Low variation: dentists who had spent most of their work time on restoration treatment and endodontics.

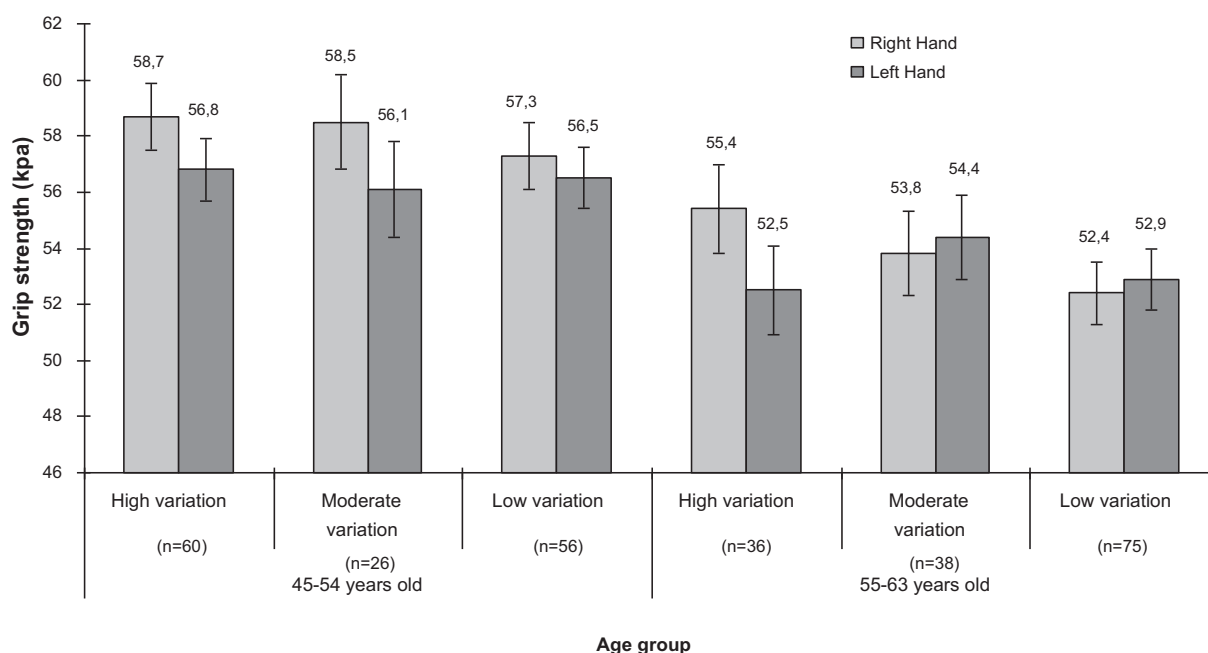


Fig. 1. Pinch grip strength of the left and right hand by age and the level of variation in dental work tasks (Mean  $\pm$  SD).

treatment and endodontics, 2) moderate variation: the dentists who had spent about half of their work time on restoration treatment and endodontics and another half on prosthodontics, periodontics and surgical treatment, and, 3) high variation: the dentists who had performed variable work tasks (Solovieva et al., 2006).

## 2.5. Other risk factors

During the clinical examination session, weight was measured (without shoes) to an accuracy of 0.1 kg. Body mass index (BMI) was calculated based on self-reported height and measured weight. Information on weekly hours of hand-loading leisure-time activities and glove size was collected by a self-administered questionnaire. The customary glove size, graded as small, medium or large,

was used as proxy for hand size. The hand-loading leisure-time activities were categorized into two groups using cluster analysis with the K-means algorithm. The majority of the subjects were classified into the low-level hand-loading leisure-time activity group ( $N = 390$ , 72%), while 28% of the women had high-level hand-loading leisure-time activity.

## 2.6. Statistical analysis

The differences in pinch grip strength between left and right hand by the level of variation in dental tasks and age groups were analysed applying generalized linear model with a repeated measures design. Logistic regression models were used to estimate the effect of age, the level of variation in work tasks and symptomatic

Table 2

Association between age, the variation in dental work task and symptomatic hand OA in the joints of the 1st-3rd finger or the wrist and low pinch grip strength.<sup>a</sup> Logistic regression analysis. Bold represents statistically significant odds ratios (OR) and their 95% confidence intervals (95% CI).

		<i>N</i> <sup>b</sup> (cases)	Unadjusted		Mutually adjusted		Adjusted also for other confounders <sup>d</sup>	
			OR	95% CI	OR	95% CI	OR	95% CI
Right hand								
Level of variation in dental work tasks <sup>c</sup>	High variation	95(18)	1.00		1.00		1.00	
	Moderate variation	64 (21)	<b>2.11</b>	<b>1.01–4.40</b>	1.67	0.78–3.59	1.78	0.81–3.88
	Low variation	130(50)	<b>2.67</b>	<b>1.43–4.99</b>	<b>2.26</b>	<b>1.19–4.29</b>	<b>2.28</b>	<b>1.18–4.03</b>
Symptomatic OA	No	260(72)	1.00		1.00		1.00	
	Yes	32(19)	<b>3.59</b>	<b>1.67–7.71</b>	<b>2.338</b>	<b>1.03–5.24</b>	<b>2.69</b>	<b>1.16–6.26</b>
Age (years)			<b>1.10</b>	<b>1.05–1.15</b>	<b>1.08</b>	<b>1.03–1.13</b>	<b>1.09</b>	<b>1.04–1.15</b>
Left hand								
Variation in dental work tasks	High variation	96(27)	1.00		1.00		1.00	
	Moderate variation	64(23)	1.47	0.75–2.90	1.28	0.64–2.56	1.34	0.66–2.75
	Low variation	131(45)	1.35	0.76–2.40	1.20	0.67–2.15	1.13	0.62–2.08
Symptomatic OA	No	270(83)	1.00		1.00		1.00	
	Yes	24(13)	<b>2.64</b>	<b>1.13–6.14</b>	2.16	0.90–5.22	<b>2.68</b>	<b>1.08–6.66</b>
Age (years)			<b>1.05</b>	<b>1.00–1.09</b>	1.03	0.99–1.08	<b>1.05</b>	<b>1.00–1.10</b>

<sup>a</sup> Cut-off point for low pinch grip strength, both hands:  $\leq 52$  kPa.

<sup>b</sup> Number of subjects (number of cases with low pinch strength).

<sup>c</sup> Level of variation in dental work tasks: High variation: dentists who had performed variable work tasks; Moderate variation: dentists who had spent half of their work time on restoration treatment and endodontics, and another half on prosthodontics, periodontics, and surgical treatment; Low variation: dentists who had spent most of their work time on restoration treatment and endodontics.

<sup>d</sup> Adjusted for other variables in the table and also for body mass index, hand size, and hand-loading leisure-time activities.

hand OA on pinch grip strength. Odds ratios (ORs) and their 95% confidence intervals (CIs) were adjusted for BMI, hand size, and hand-loading leisure-time activity. The analyses were performed with the SPSS (version 14.0 program).

### 3. Results

The distribution of subject characteristics by the level of variation in dental work tasks is presented in Table 1. Dentists with a history of high work task variation were somewhat younger than those with less variation in their work task history ( $p = 0.02$ ). The groups did not differ with respect to other assessed characteristics. The prevalence of symptomatic OA in the joints of the first three fingers or the wrist was higher in the right hand than in the left hand (right vs. left: 10.9% vs. 8.2%,  $P < 0.001$ ).

Pinch grip strength decreased with age in both hands and with decreasing level of variation in work tasks in the right hand (Fig. 1). Among the dentists aged 45–54 years, the pinch grip strength in the left hand was lower than that in the right hand independent of variation in work tasks, but among the older age group (55–63-years), a similar pattern was observed only in those who had performed variable work tasks.

#### 3.1. Variation of work tasks in working history and pinch grip strength

We examined the association of variation in dental work task history with pinch grip strength separately by hand (Table 2). In unadjusted analyses regarding the right hand, the dentists with low (OR 2.67, 95% CI 1.43–4.99) and moderate (2.11, 1.01–4.40), variation in work tasks had a higher risk of low pinch grip strength compared with those who had performed variable work tasks. Including age and symptomatic hand OA in the model attenuated the association between moderate task variation and low pinch grip strength, but the association of low task variation with low pinch grip strength persisted. Further adjustment for other covariates (body mass index, hand size and hand-loading leisure-time activity) had little effect on the estimates. In the left hand, no association between the variation in work task history and low pinch grip strength was observed.

### 4. Discussion

The functional integrity of the human hand comprises adequate pinch grip strength, which is needed in dealing with the demands of hand use in daily life and in many occupational activities. OA-related impairment in grip force production has been shown to lead to a decline in hand function while performing tasks that require using a power or precision grip (Stamm et al., 2002).

We found among middle-aged female dentists that low variation in dental work history, with tasks predominantly in restoration treatment and endodontics, was associated with low pinch grip strength in the right hand independent of age and symptomatic OA. No such relationship was observed in the left hand. We repeated the analyses excluding the left-handed subjects, but the results remained the same. This may be because of the low number of left-handed dentists in our study group (2.7%).

Our findings are in line with previous studies which showed that a long history of repetitive manual work was associated with impaired hand function (Young et al., 1995; Russo et al., 2006). The effect of physical workload in dentistry on the occurrence of hand/wrist problems has been investigated (Alexopoulos et al., 2004; Solovieva et al., 2006; Dong et al., 2007). In the present study material, low variation in dental work task history was related to OA in the joints of the thumb, index, and middle fingers (Solovieva

et al., 2006). We have also reported that symptomatic hand OA increased the risk of low pinch grip strength (Ding et al., 2010). The results of the current study suggest that the level of variation in dental work tasks affects pinch grip strength both directly and indirectly via symptomatic OA. It is known that the loss of hand function is associated with age (Carmeli et al., 2003). Even though reduced pinch grip strength is an inevitable consequence of ageing, skilled finger exercise can improve hand function in older persons (Ranganathan et al., 2001b) and in those with OA (Kjeken, 2011). The effect of hand usage at work on hand function is likely also more complex, since both under use and overuse of the hand joints have been associated with a decline in hand strength (Parlitz et al., 1998; Ijmker et al., 2007).

Traditionally dentists performing clinical procedures use their working hand, most frequently the right hand, to rotate hand pieces and other hand instruments, having a mirror in the left hand for facilitating vision to the working site or for retraction of oral soft tissues. Stereotyped repetitive dental tasks for prolonged periods may lead to overuse of the thumb, index finger, and middle finger, and may consequently increase the risk of right hand function impairment in dentists with low variation in work tasks. In accordance with this we observed that the age-related decline in the pinch grip strength of the right hand was steeper among dentists with low variation in work tasks than among dentists with high variation. The decline was so marked that in the older group of dentists aged 55–63 years, pinch grip strength in the right hand was lower than that in the left among those who had had moderate or low work task variation. It is also possible that there was a training element in the use of the left hand among dentists with moderate and low task variation. Thus, our finding suggests that hand overuse may accelerate the decline in hand function with age, while appropriate hand loading activity may counteract the age changes in pinch grip strength and might even improve hand function.

In the current study, the level of variation in dental work tasks was empirically defined based on detailed self-reported information about dentists' work history. In such a situation some recall bias may be induced particularly when work history is long. Although we lack specific information on the reliability of this assessment, we assume that well-educated middle-aged women, most of whom were still actively working in the field, recalled their work history adequately enough for our purposes, where the overall variation in work tasks was described by three categories. We defined low pinch grip strength based on its distribution in the material, and its significance for e.g. managing dental work tasks should be addressed in future studies.

We used the jointwise co-occurrence of radiological findings and pain to define symptomatic hand OA. This was done to imitate, in an epidemiological setting of a random sample of dentists, the clinical disease where both symptoms and findings are relevant. In our previous study (Ding et al., 2010) we found that symptomatic radiographic OA, but not radiographic findings or symptoms alone, was associated with decreased pinch grip strength.

In conclusion, we found that the dentists with the most hand-loading tasks were at an increased risk of low pinch grip strength, independent of hand OA. This draws attention to work arrangements that could counteract deterioration of hand function, as adequate hand function is a prerequisite for continued occupation as a dentist. The dentists with low variation in work tasks need to modify their work practices and if possible, to perform diversity of work tasks in order to reduce the risk of developing hand disability. Since work-related musculoskeletal problems and loss of hand function may lead to absence from work and even early retirement among the dentists (Burke et al., 1997), learning work ergonomics already during their undergraduate clinical training is to be recommended.

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